

MULTIBAND PLANAR INVERTED-F ANTENNA (PIFA) FOR MOBILE PHONES

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ABSTRACT

The proposed antenna consists of the radiating patch of dimension 71mm×21mm, and the finite ground plane of dimension 90mm×26mm. Both are made by 0.2 mm thick copper foil. The thickness of air (dielectric material layer) is 5mm. A probe feed of radius 0.35 mm is inserted. Techniques such as shorting plate, a parasitic element, and shorting pins are also carried out in the proposed antenna design. The proposed antenna is designed and simulated using Transmission Line Model and HFSS software in the frequency range 1-6 GHz. After simulation, three bands are obtained at resonance frequencies of 1.975 GHz, 3.5GHz and 5.45GHz. The return loss of -12.8 dB, -30.9 dB and -33.7 dB are found at corresponding resonance frequencies. The bandwidth of 41.9MHz, 977.6MHz and 261.2MHz as well as normalized radiation efficiency of 62%, 61.6% and 93% for the proposed antenna are seen. The corresponding gains of the proposed antenna are found to be 4.5 dB, 6.19 dB and 6.0 dB. Performance parameters of the proposed antenna are greatly improved with the antenna under reference. The proposed antenna is fabricated and measured. The simulated and measured results are compared and they have good agreement. The proposed antenna is useful for mobile phone covering PCS 1900 & WIMAX at 3.5 GHz & 5.5 GHz, respectively.

KEYWORDS: Fabricated Antenna, Internal Antenna Multiband, Planar Inverted-F Antenna (PIFA).

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INTRODUCTION

Presently, a mobile communication system includes voice, data, moving images and digital TV broadcasting. Very rapid growth in mobile communication systems has lead to a great demand to develop very small antenna with multiband and broadband function for avoiding the use of two and more antennas in the same mobile phone. Therefore, there is demand for a small, light and thin microstrip patch antenna which meets the requirement of multiband operation [1-2]. The mobile phone continues its minimization in terms of compact size antenna provided that its performance is not compromised. Mobile phones are having either an external antenna as monopoles (whips) & helical or an internal antenna as Micro Strip Antennas (MSA) & Planar Inverted-F Antennas (PIFA). Internal antennas over external antennas are much preferred for mobile handset as they are less prone to damage, compact in size, etc. Therefore, Planar Inverted-F Antenna (PIFA) is used as an internal antenna

PIFA is a promising design because it is small and a quarter wavelength microstrip antenna. PIFA antenna promises to be a good choice for future technology due to its flexible structure. PIFA may be easily integrated into the wireless mobile equipments [3-4]. A PIFA consists of a ground plane, radiating patch, shorting pin, shorting wall and feeding. The common PIFA has a rectangular element with an omni-directional radiation pattern and exhibits a reasonably high gain. The bandwidth of the PIFA is broad enough for mobile communication. It is also highly sensitive to both vertically and horizontally polarized electromagnetic waves of high frequency and therefore, PIFA

is suited to mobile applications [5-9].

Numerous researchers have studied different structures and techniques to increase the bandwidth and to make an antenna multiband with reasonable gain. It becomes necessary to make PIFA antenna multiband and broad band for mobile phones. The objective of the work is to design, simulate, analyse the antenna parameters, fabricate, and measure the multiband PIFA antenna for mobile phones. The proposed antenna is found to work for PCS and WIMAX applications.

PCS is a wireless phone service. It resembles with cellular telephone service but emphasizing extended mobility and personal service. In commercial terms, PCS is a generation of wireless-phone technology that facilitates users with all in one wireless phone, messaging, paging and data services [10].

Worldwide Interoperability for Microwave Access (WIMAX) commonly termed as 4G network. It is a WAN working function of DSL lines, with no wires. The WIMAX forum describes WIMAX as "a standards-based technology enabling the delivery of last mile wireless broadband access as a substitute to wire". It makes free VoIP and cheap phone calls using a WIMAX enabled mobile phones and laptop [11-13].

The fabricated antenna has been measured through Vector Network Analyzer (VNA) in terms of return loss & Voltage Standing Wave Ratio(VSWR).The radiation pattern of E Field & H Field for the fabricated antenna have been measured in anechoic chamber using horn antenna as a reference antenna and the data is stored in the computer. The fabrication and the measurement of the proposed antenna is successfully completed and is found suitably to work in range of 1-6 GHz for mobile phone applications. Good radiations patterns are achieved because low losses occurs due to air/foam as dielectric substrate [14]. The proposed antenna has resonated at three frequencies 1.975 GHz, 3.5 GHz and 5.5 GHz having gain of 4.48 dB, 6.18 dB and 6.0 dB, respectively. The normalized radiation efficiencies at these corresponding frequencies are 62%, 61.6%, & 93%. Therefore, the proposed antenna is suitable for 3.5GHz/5.5GHz WIMAX and 1.9 GHz PCS applications of mobile phones. The simulated and the measured results of the proposed PIFA antenna have been compared and there is a close agreement between them.

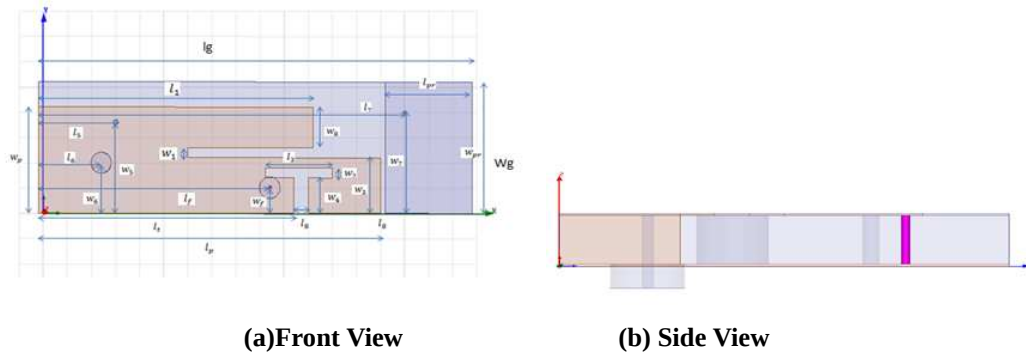
MATERIALS AND METHODS

Figure.1 (a)-(b) shows the geometry of the proposed antenna. The dimension of the radiating patch calculated by transmission line model is 71mm×21mm. The patch and the ground plane are of copper foil of 0.2 mm thickness with a shorting plate of 0.2mm thick. The rectangular patch with rectangular, I and T shaped slots is the main radiating element of proposed antenna. Three slots provide broadband at particular frequencies; shorting pins and parasitic element provide better gain and multiband. The dimension of ground plane is taken as 90 mm × 26 mm. The resonance frequencies are 1.975 GHz, 3.5 GHz and 5.45GHz. Three frequency bands with gain of 4.5 dB, 6.18 dB & 6.0 dB and wide bandwidth are obtained. The normalized radiation efficiencies are obtained as 62%, 61.6% and 93% at 1.975 GHz, 3.5 GHz and 5.45GHz, respectively. Table 1 shows the dimensions for the proposed antenna.

To obtain the desired multiband using ansoft HFSS the dimensions and locations of the patch, ground plane, slots, shorting pins, shorting plate and parasitic element are optimised. Fig. 2 shows the proposed fabricated antenna.

The antenna is fabricated using arlon(foam) instead of air as dielectric substrate as in fabrication air is not used and it cannot provide support. The parameters of the fabricated antenna are measured using VNA and anechoic chamber. The arlon(foam) has similar dielectric properties as air. Therefore, there is some dissimilarity in measured and simulated

results.



(a)Front View

(b) Side View

Figure 1: Geometry of the Proposed Antenna



Figure 2. Proposed Fabricated Antenna

Table 1: Antenna Dimansions(Mm)

l_p	71	l_8	3	l_q	90
w_p	21	l_5	16	l_6	13
w_q	26	l_7	76	l_4	7
l_1	57	w_s	7	l_{pr}	18
w_1	2	w_6	10	l_t	52
l_2	14	w_8	10	l_2	14
l_5	5.2	w_5	18	w_{pr}	26
w_2	2	w_7	26	w_2	11
l_f	48	w_f	5.1	w_4	3

RESULTS AND DISCUSSIONS

The simulations are performed in Ansoft HFSS. Fig. 3(a)-(b) shows the simulated return loss v/s frequency and VSWR v/s frequency graph which demonstrate the proposed antenna work at three frequencies 1.975 GHz, 3.5GHz and 5.45GHz with 41.9 MHz, 977.6 MHz and 261.2MHz bandwidth, -12.8dB, -30dB and -33.7dB maximum return losses. The gain v/s frequency and the normalized radiation efficiency v/s frequency of the proposed antenna are plotted in Figure 3(c)-(d). These graphs shown in Fig. 3(c)-3(d) depict the gain 4.5 dB, 6.18 dB & 6.0 dB and normalized radiation efficiencies of 62 %, 61.6 % & 93 % for the proposed antenna at the corresponding resonance frequencies in the frequency range 1-6 GHz.

Figure 4 shows the 3D radiation pattern of the proposed antenna representing reasonable gain of 4.5dB, 6.19dB and 6.0dB at frequencies of 3.5 GHz, 1.975 GHz, and 5.45 GHz, respectively. Comparisons of the fabricated and proposed antenna in terms of return loss, VSWR, and polar radiation patterns at different fields are given in Figs. 5-6. It is obvious from these figures that the simulated and measured results have good agreement. Fabricated antenna having good radiation

patterns covers three frequency bands, 1.89-2.01GHz, 3.1-3.9GHz and 5.34-5.58GHz bands that are seen from the measured results.

Table 2 and Table 3 describe the various comparisons in terms of the antenna parameters & the design of the proposed antenna and the antenna under reference (Agarwal m. et al. 2009). They also illustrate that the proposed antenna is better than the antenna under reference in terms of its size, volume and parameters.

Table 2: Comparison of the Antenna Parameters for the Proposed Antenna and the Antenna under Reference (Agarwal M. Et Al. 2009)

Parameters	Antenna Under Reference	Proposed Antenna
Frequencies (GHz)	1.595 3.41,3.69	1.975 3.275,3.5, 5.45
Bandwidth (MHz)	20, 500	41.9, 977.6, 261.2
Bands	Dual Band	TripleBand
Gain (dB)	5.29, 5.56	4.5, 6.18, 6.0
Return Loss (dB)	-20 -37	-12.8 -30.9 ,-26.2, -33.7
Applications	GPS,WIMAX	PCS,WIMAX

Table 3: Design Comparison of the Proposed Antenna and the Antenna Under Reference (Agarwal M. Et Al. 2009)

Parameters	Antenna Under Reference	Proposed Antenna
Ground size	100mm×24mm	90mm×26 mm
Dimension of the radiating patch	71mm×22 mm	71mm×21 mm
Height of the antenna	9.7mm	5.4mm
Antenna volume	100×24×9.7 mm ³	90×26×5.4 mm ³
Radius of probe feed	Not given	0.35mm
Width of shorting plate	5mm	7mm
Substrate height	9.3mm	5mm
Ground plane slot Lengths	1mm	No slot
Shapes of slot in patch	Rectangle Shape Slot	Slots of Rectangular, T and I shape in the patch
Feed position	(44,0)	(47,5.1)
Parasitic element dimensions	27×13 mm ²	18mm×26 mm
Shorting pin	No shorting pin	3 Shorting pins
Distance between the patch and the parasitic element	2mm	1mm
Simulated/ fabricated/ measured antenna	Only simulated	Simulated , fabricated and measured

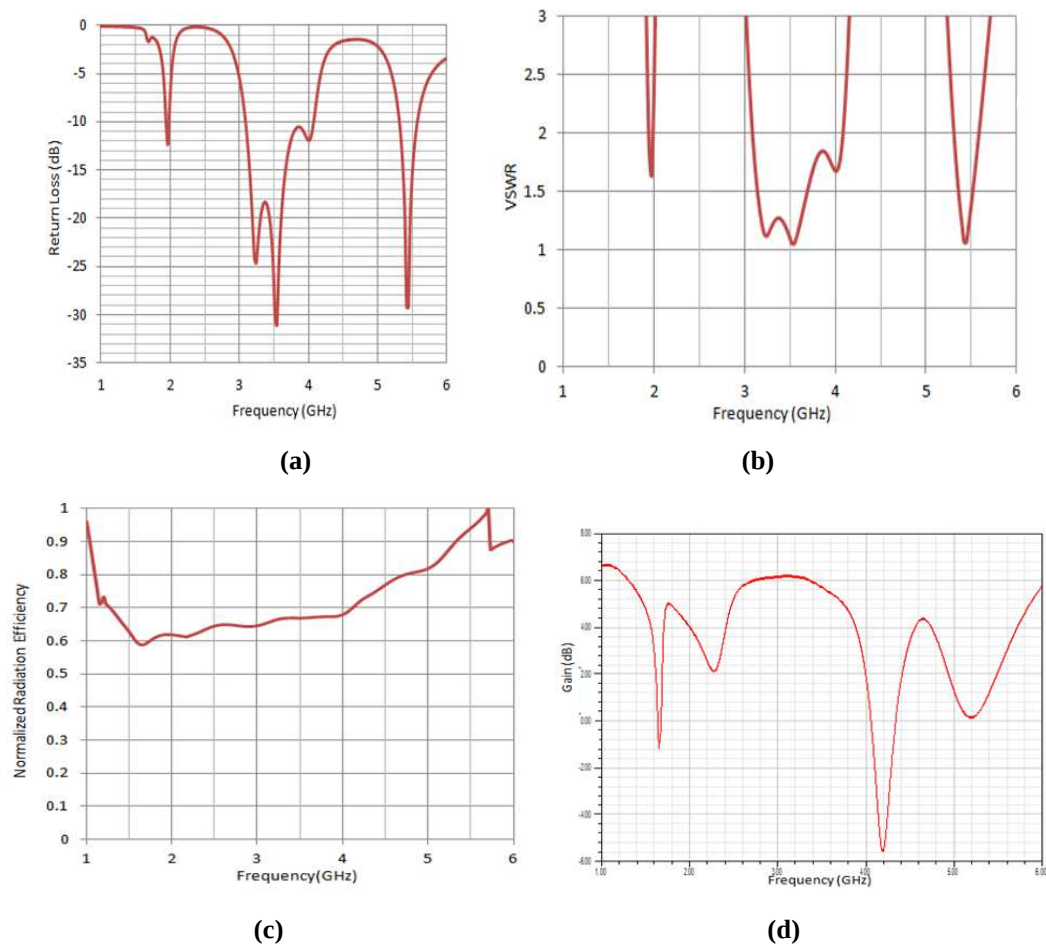


Figure 3: Various Simulated Results of the Proposed Antenna in Terms of (a) VSWR V/S Frequency (b) Normalized Radiation Efficiency V/S Frequency, and (c) Gain V/S Frequency

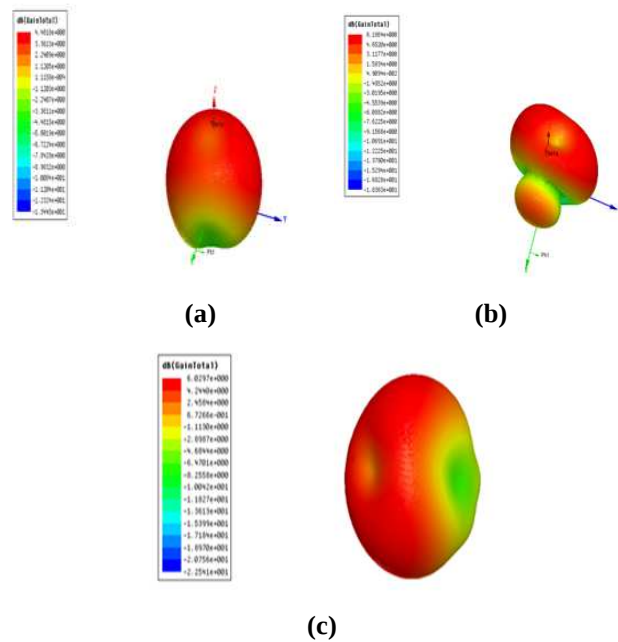


Figure 4: Radiation Patterns of the Proposed Antenna at Different Frequencies (a) 1.975 Ghz (b) 3.5 Ghz (c) 5.45 Ghz

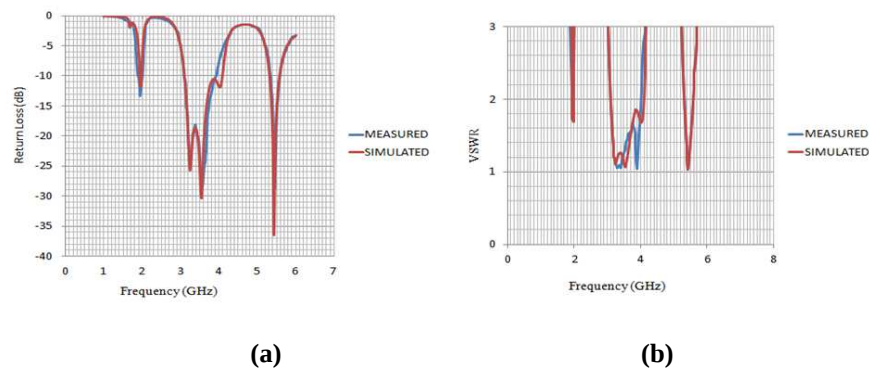


Figure 5: Comparison of the Simulated and Measured Results for Fabricated and Proposed Antenna in Terms of (a) Return Loss V/S Frequency and (b) VSWR V/S Frequency

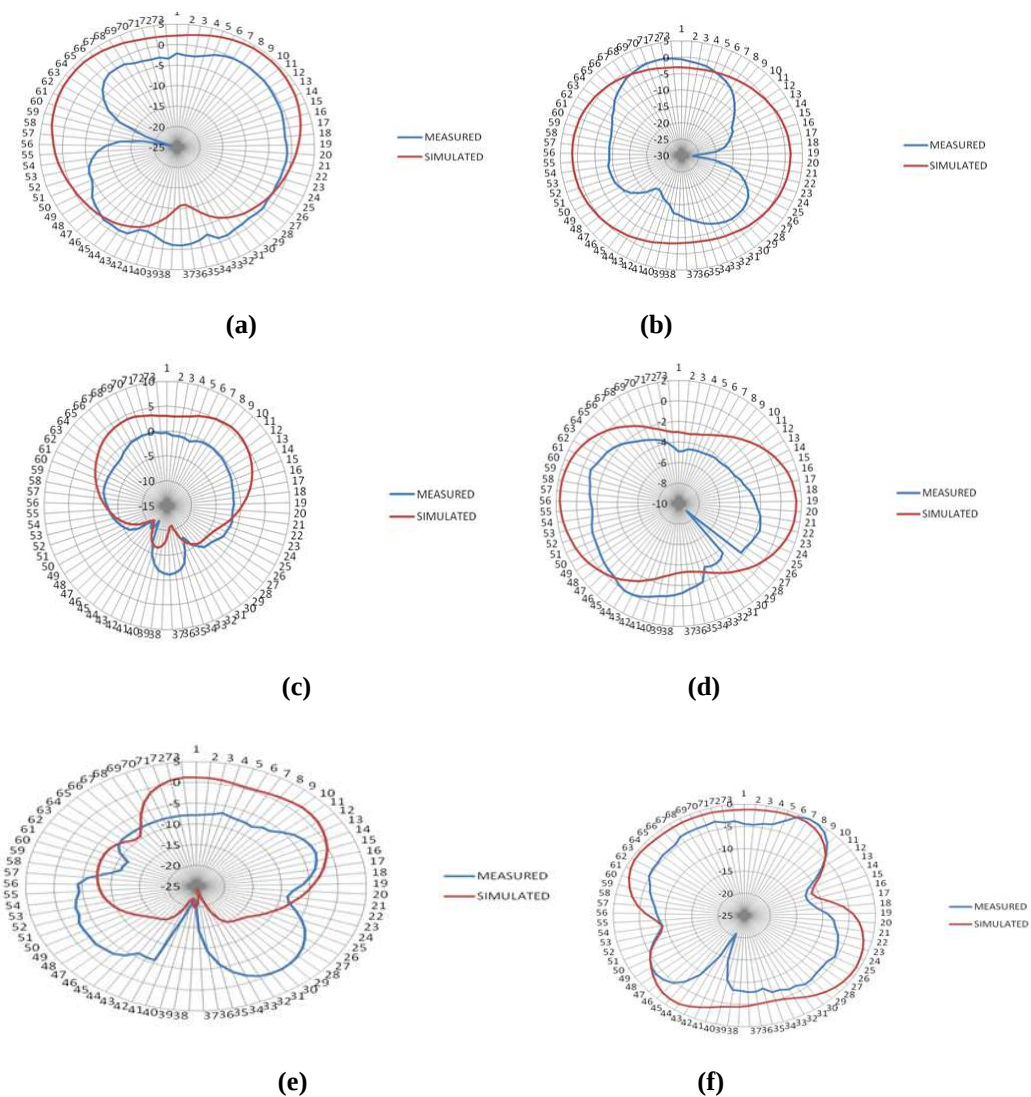


Figure 6: Comparison of the Simulated and Measured Polar Radiation Patterns for the Proposed Antenna at Different Fields for (a) Magnetic Field at 1.975 Ghz, (b) Electric Field at 1.975 Ghz, (c) Magnetic Field at 3.5 Ghz, (d) Electric Field at 3.5 Ghz, (e) Magnetic Field at 5.45 Ghz, and (f) Electric Field at 5.45 Ghz

CONCLUSIONS

The proposed antenna works in the mobile phone communication at three resonance frequencies at 1.975GHz for PCS and at 3.5GHz & 5.45GHz for WIMAX. It is found that the proposed antenna is better than the antenna under reference (Agarwal M. et al. (2013)) in terms of bands and bandwidth. Also, the antenna volume is reduced to 45% from the antenna under reference. It is found that there is a close agreement between the simulated and the measured results for the proposed antenna. Therefore, the proposed antenna found to be more useful in mobile phones. The future scope of this antenna lies in coming future tabs and mobile phones.

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